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area, would be needed to make conclusions of any value. From the Weather Bureau reports at our disposal from stations from Milwaukee to Dubuque, some of them going back to 1871, it does not appear that there has been any significant change. The last decade includes dry years and wet years, dry and wet summers.

The influence of deforestation on the character of the flora is another interesting subject. While the relative representation of different components of the flora has of course changed profoundly, remarkably few plants have as yet become extinct. No tree has certainly disappeared except the juniper, which had a single locality and has not been seen within thirty years. We have the only local herbaria of any size, that of Herbert E. Copeland dating from the early seventies, and our own, mostly about seventeen years later. The only plants whose disappearance in that interval is highly probable are *Camassia Fraseri* and *Pogonia pendula*. In the last fifteen years *Cypripedium spectabile*, *Gaultheria procumbens*, *Phegopteris Dryopteris*, and possibly as many more plants all strictly local, seem to have been killed out. On rare rough hillsides and in gulches where the timber is relatively native, and in fence corners, in brush, or around stumps, the old flora persists. It is a most instructive lesson in the survival of what exists that above thirteen-fourteenths of the native habitat has been altogether changed in character, and the other one-fourteenth decidedly modified, without the extinction of a single common forest herb, shrub, or tree.—F. A. SHRINER and E. B. COPELAND, *Monroe*, *Wis.*

THE EFFECTS OF EXTERNAL AGENTS ON THE PRODUCTION OF ROOT HAIRS.

PRELIMINARY NOTICE.

DURING an endeavor to find the causes for the production of root hairs, results were obtained, which, though incomplete, may be of sufficient interest to warrant publication.

Seedlings of *Zea mais*, *Helianthus annuus*, *Lupinus albus*, *Avena sativa*, *Triticum vulgare*, *Vicia sativa*, *Cucurbita Pepo*, *Raphanus sativus*, *Brassica alba*, and *Cannabis sativa*, grown in water, showed a tendency not to develop typical water roots at once, but produced a longer or shorter zone of hairs, passing, in some forms, into the smooth surface usually characteristic of water roots. Apparently this zone of hairs in sunflower, radish, and white mustard was not directly influenced by light or darkness.

In solutions seedlings showed a general tendency for the hair development to vary with root development, though the results are rather discordant, and more work is required before any conclusion can be reached. The roots seem to be able to bear higher percentages of saccharose than of lactose, glucose, glycerin, mannite, or modified Knop's solution, a result in accordance with that of Livingston. The discordance of results above mentioned may be due, in part at least, to the absorption of different chemicals from the different kinds of glass in the vessels used, since Benecke found such absorption to influence the development of rhizoids in Lunularia.

The effect of the quantity of food is of importance, apparently, because of its influence upon the growth of the root. Seedlings of Helianthus, whose cotyledons had been cut off at various distances from their insertion, produced different root lengths corresponding to the lengths of cotyledons remaining, and the hair development varied accordingly.

The oxygen pressure in water was varied by boiling, with no very marked difference in the hair production of corn seedlings. Further experiments in variation of oxygen pressure are in progress.

From the cases mentioned there appears to be a tendency for seedlings under most conditions to produce a longer or shorter zone of hairs, probably on account of the surplus energy provided by the stored food.

The growth of roots is more rapid in water than in air of the same temperature (as has frequently been noted), with hair production in inverse relation; the water condition appears to be produced, however, in saturated air. The average length of epidermal cells in water roots exceeds that of the same cells in air roots, though the average number of cells produced each day appears to be approximately the same under the same conditions. Therefore the increased length, in this case at least, seems to be due to greater elongation of the cells of the water roots. In the same section there appears in general to be a relation between the length of the cells and the production of hairs, the average length of hairless cells being greater than that of cells with hairs.

A retardation of growth when the root tip meets with resistance causes the root to kink and produce hairs. If wounded, the growth is also retarded, and the region immediately behind the tip usually becomes abnormally enlarged, and at the same time shows a marked tendency to form hairs.

In accordance with the statements of Haberlandt and Schwartz, Elodea roots, though hairless in water, produce hairs when growing in the substratum of the aquarium, even if the material be ground quartz. Microscopic examination has shown thus far that the average length of epidermal cells of roots in the substratum is less than that of epidermal cells of roots in the water. The presence of hairs seems to be related, therefore, to the length of the cells rather than to superficial contact. In support of the idea that contact of the epidermal cells with solid bodies does not appear to bé a stimulus for hair production, may be cited certain instances where roots of seedlings grew against the sides of a glass vessel; in this condition there was a marked tendency for the suppression of hairs along the region of contact. Also seedlings grown in saturated sand or garden soil show a diminution or even absence of hairs, as previously indicated by Persecke.

That temperature has an effect, though possibly an indirect one, upon hair production is evidenced by roots of corn and wheat seedlings showing a tendency to omit the hair zone when growing rapidly in warm water.

From the foregoing statements there appears to be a relation between the production of root hairs and the elongation of the cell; whatever has a tendency to increase the elongation also tends to suppress the development of hairs, "water etiolation" being especially important in this connection in soil roots. In two cases of decapitated sunflower seedlings the water etiolation of the periblem and epidermis was apparently so great that the poorly nourished, deeper lying plerome was not able to keep pace with it and hence split transversely in several places. The frequently noted decrease of hairs in etiolated conditions of the aerial parts of plants, whether from darkness or moisture, supports this view.

The production of hairs coincident with slow growth above mentioned is not thought to be due to excess of nourishment, as supposed, but merely to the tendency of the cells to grow transversely rather than to elongate longitudinally. This is supported by the condition of affairs in Lycopodium and Isoetes, and by Leavitt's association of root hairs of Azolla with cells which do not elongate. The root hair problem therefore, appears, to resolve itself in large part into the search for the causes of arrested growth or the elongation of cells.

Other references, illustrations, and conclusions will be reserved until the work is more complete. — LAETITIA M. SNOW, *Hull Botanical Laboratory, The University of Chicago.*